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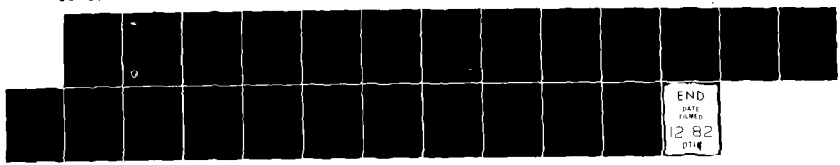

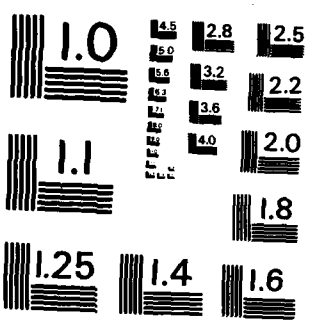

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LARGE PRINT SYSTEM ON A GRAPHIC COMPUTER TERMINAL FOR VISUALLY HANDICAPPED PROGRAMMERS

AUGUST 1982

By

T. L. Barber

E. B. Stenmark

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US Army Electronics Research and Development Command

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For the person with normal vision, an interactive cathode ray tube terminal with graphic capability is a useful two-way window to the operation of a computer. For an individual with very limited vision, such a device is difficult if not impossible to use because of the small alphanumeric print size. A software-generated graphic print set has been developed for a Tektronix Model 4016-1 terminal. This print set operates as automatically as the alphanumeric print sets that are a part of the terminal. The print can be

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20. ABSTRACT (cont)

adjusted from some arbitrarily small size to 2 inches in height. With this capability, the terminal can be very useful to an individual with very poor vision.

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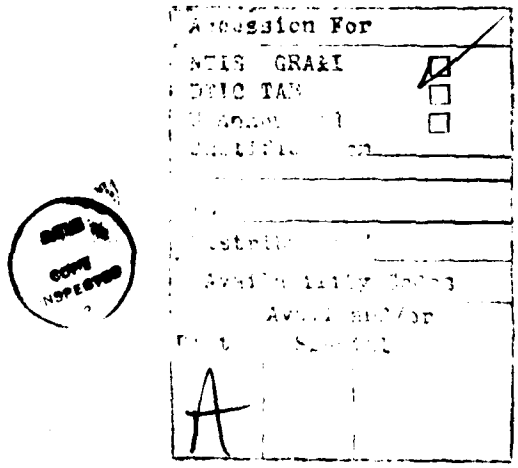

CONTENTS

LIST OF FIGURES

INTRODUCTION

The proliferation of computer systems in all areas of scientific endeavor and in much of the business world has made it highly desirable, and indeed necessary, that some individuals with very limited sight be able to interact with computers in much the same manner as the fully sighted through the use of demand terminals.

For the majority of the population, the video display terminal can be a window into the world of the computer, through which it is possible to view alphanumeric input and output with no difficulties. However, for individuals with limited vision, the video screen terminal presents major difficulties and exists as a heavily curtained window if not a completely blank wall. For many such individuals the primary difficulty lies with the small size of the alphanumeric characters displayed on such terminals. Even on the few terminals currently available that provide hardware or firmware implementation of optional character sizes, the largest available character size is usually too small to be easily readable by many.

This paper describes one solution to this character size problem: use of the graphics capabilities of a large-screen intelligent terminal through software implementation of a controllable scale, alternate print set. The authors will gladly copy the program, free of charge, onto the disc of anyone desiring to use this large print system.

DISCUSSION

Problem

Effective interaction with a computer system through a demand terminal requires that the individual be able to 1) use the keyboard to input numbers, characters, and control codes; 2) recognize and correct keyboard input errors quickly and easily; and 3) easily read output resulting from computer processing of his keyboard inputs. Even though he can easily accomplish the first of these three requirements, the individual with poor vision (50 to 2 percent residual sight) is prevented from accomplishing the second and third with standard video display terminals because the print displayed is too small for him to conveniently read.

Optical magnification, a viable option for reading most printed materials, is extremely difficult in this instance, because of the physical characteristics of video display terminals and the dynamic nature of the displayed print. Another option sometimes available to the individual with poor vision, that of having another person read for him, is at best a very poor use of man-power.

Solution

A solution to the stated problem was developed by having a large-screen intelligent terminal (Tektronix 4016-1) produce print graphically. This graphics print software system is loaded into the terminal memory and resides there as

long as power to the terminal remains on. This alternate graphics print set can be scaled to produce screen characters 1 inch or more in height, making it much easier for the person with poor vision to read.

Each keyboard key that has a standard ASCII printable character associated with it has a string of graphic codes associated with it under the alternate character set option, which produces a multiple-line drawing of that particular print character to a prespecified controllable scale size whenever the key is struck by the operator. Simultaneously, the correct, unaltered ASCII code for the particular character is sent to the host computer. Likewise, ASCII codes received by the terminal as output from the computer result in the comparable characters being drawn on the screen rather than the standard size print characters being displayed.

The graphics print system operation is thus transparent both to the host computer and to the terminal operator once the system is properly loaded into terminal memory and activated.

Graphics Print Set Development

Each character in the alternate graphics print set was initially produced using the design mode of the Tektronix 4016-1 terminal. An example of one such character as it appears on the screen in design mode is shown in figure 1.

The baseline for the "B" is seven-twelfths of the design mode vertical dimension up from the bottom, while the letter is bounded on the left by the design mode centerline. The characters were "designed" in the upper right quadrant in order to facilitate the graphic implementation of the line feed and backspace. A graphic line feed consists of a move command for the graphic cursor from the current character position baseline down one full character height (five-twelfths of full screen), plus two-fifths of character height (two-twelfths of full screen), to allow for clearance between lines of print. The graphic backspace consists of movement of the cursor one full character space (one-half of full screen) to the left.

The benefit of graphically programming the backspace and line feed as functions of character space width and height is that as the print size is changed with the graphic scale command, the line feed and backspace change proportionally and relative spacing of characters both vertically and horizontally remains the same. As can be seen in figure 1, the graphic characters are drawn with three parallel lines in each segment, which in the most usable character sizes results in an apparent single heavy line or bar-type character structure, with enhanced contrast for better readability.

As each character was completed in design mode, it was stored referenced to the appropriate key on the keyboard. The full set of printable ASCII characters, including upper- and lower-case alphabet, have been implemented in the alternate graphics print set.

Margin Control

One major difficulty encountered in the development of the graphics print set involved the margin control system built into the Tektronix 4016-1. When operating with any of the four standard print sizes available in the 4016-1, the system automatically detects a line of print reaching the right edge of the screen. When this occurs, the cursor beam is moved horizontally to the left edge of the screen and down one standard line space (one character height plus line clearance) prior to printing the next character. This movement is comparable to a line feed and carriage return but does not actually involve either of these control functions.

The problem of margin control for the graphics print set is two-fold: first, the automatic detection of the right edge of the screen does not occur with the graphics characters produced in design mode; and secondly, when the cursor beam does move to the left edge and down for a new line of print, the vertical downward movement is only that appropriate to the small, standard print sizes. Thus, in the first instance, characters are effectively lost off the right side of the screen, and in the second, the large graphics print on a new line vertically overlaps a large part of the previous line.

The first problem was solved by making a relatively minor modification to the string of graphics codes that are stored for each print character. As produced by the design mode, the graphics string begins with a control code to turn on graphics mode and ends with a control code to return to alphanumeric mode. If the nonprinting ASCII space character is attached to the end of the graphics string, then when the graphics string completes its function at the right edge of the screen this appended ASCII space character is sensed by the system margin control in the normal manner, and the cursor beam is returned horizontally to the left edge of the screen and is moved down one standard line space. With this modification made to each of the stored graphics code strings, graphics print characters were no longer lost off the right side of the screen. However, the vertical overlap problem still existed.

This second problem was solved by imposing a slight angular rotation in the clockwise direction on all graphics. A line of graphics print produced with this imposed rotation slopes downward from left to right and finishes lower on the screen than it began. Now, when the cursor beam returns to the left screen edge and drops down one standard line space, it will be positioned far enough below the previous line to prevent overlapping. The amount of rotation required is dependent upon the character size for consistent line spacing to be maintained, but is quite small for all practical character sizes. For example, at the default scale factor of 16, the screen characters are approximately 1 inch in height and a rotation angle of 2° is sufficient to avoid the overlap problem. A slope of 2° is barely noticeable and is not at all objectionable. This example is shown in reduced scale in figure 2.

Print Size Scaling

The graphic scale command of the 4016-1 permits selection of a scale factor ranging from 1 to 256, with a default value of 16. An example of the print resulting from various scale factors, including the default scale factor, is

shown in actual size in figure 3. For a programmer with vision measuring 5/200, the default size is adequate and makes the terminal operation convenient.

One cannot practically use scale factors larger than about 50, since at the larger sizes so few characters will fit on the screen. Conversely, scale factors smaller than 4 will produce a very high density of information on displays of very small characters that, while well-defined, are readable only by someone with normal vision. The practical range of print scale values is therefore somewhat limited.

Interactive Graphics

The chief advantage of the large-character-size graphics print set is that it enables the individual with impaired sight to interact with a computer in strictly alphanumeric input/output. The graphic print set also provides advantages in the use of the Tektronix Interactive Graphic Package (IGP). The IGP system is designed to permit interactive development of various types and sizes of data graphs. Normally, the axis notations and labeling are produced by the standard alphanumeric print set built into the terminal. These characters are thus equivalent to the standard alphanumeric character sizes and are too small for the visually handicapped programmer/scientist to read conveniently.

If, however, the alternate (graphical) print set is turned on when IGP is active, the axis notations and labels will be drawn at the selected scale size (figure 4). Once the programmer/scientist has determined that the graph values and labels are correct and as he wants them, the graphic print set can be turned off and the graph redrawn (figure 5). Hardcopy output from IGP may then be obtained by direct copy of the screen display or by drawing the graph on a digital plotter, depending on the available hardware configuration. If the reader wishes more information concerning this software system or the use of the software itself, the authors should be contacted.

Additional Applications

As mentioned in the discussion of graphic print set scaling, use of small scaling factors produces very small characters on the screen. When preceded by a system command to refocus the cursor beam to draw a very fine line, the activation of the alternate graphics print set with a scale of one produces a very high density of information on the 4016-1 screen, which is readable by anyone with normal vision. A maximum of 300 lines of 440 characters each can be displayed. The determination of specific uses for such a high-density display is left to the imagination and ingenuity of the reader.

In terms of large print scales, the system may prove to be useful to the nonvisually impaired in classroom situations, where it may be desirable to be able to read displays of alphanumeric information on a computer terminal at distances of 15 to 30 feet.

When used with the IGP, the graphics print set provides additional flexibility in selection of character sizes for legends, labels, and headings of graphical material.

SUMMARY

A graphics print set that is completely usable interactively by an operator with very poor vision has been developed on a large screen computer terminal. When the software for the graphic print set is loaded into the terminal memory and the alternate print set is turned on, an automatic printing system becomes available. The scale factor can then be used to adjust the print size to the minimum the individual can comfortably read on the terminal screen. Many visually handicapped programmers/scientists can make full unassisted use of a terminal and computer in a manner that would otherwise be very difficult, if not impossible. Typed information can easily be checked for accuracy, and any error messages the computer produces can be noted. Program results and data are readily examined. Results in the form of graphics can be set up, examined by the operator, and placed in final form through use of the large print capability.

This same graphics print system can be useful to operators with normal vision. With a scale factor of 1, high information density can be available on the terminal screen. The 25-inch screen with large print can be used as an instructional aid in a classroom situation, making it possible for the entire class to see computer input and output. The variable print size capability can be quite useful when preparing graphic output, permitting greater flexibility in making up legends, labels, and headings.

The principal purpose and advantage of the graphics print system is that it makes a computer system completely accessible to programmers/scientists with as little as 2 percent residual vision.

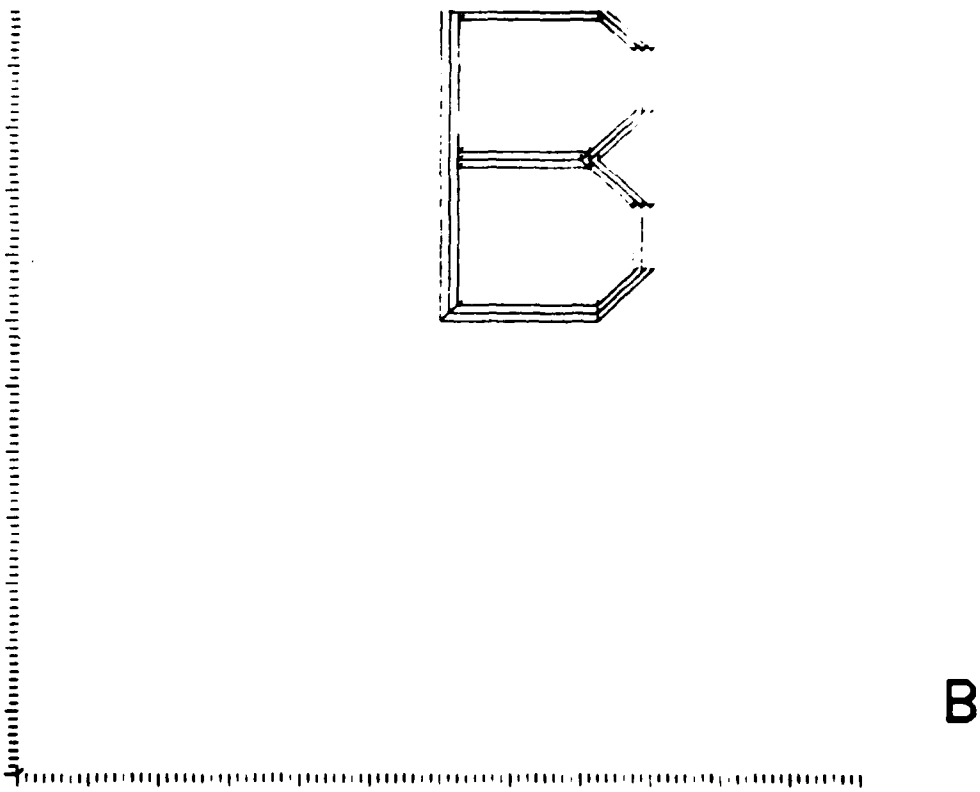

Figure 1. A Tektronix Model 4016-1 terminal in design mode. The letter B was drawn on the screen using the move and draw command. The three-line structure can be easily seen in the B. It should be remembered that the diagonal dimension of the screen is 25 inches.

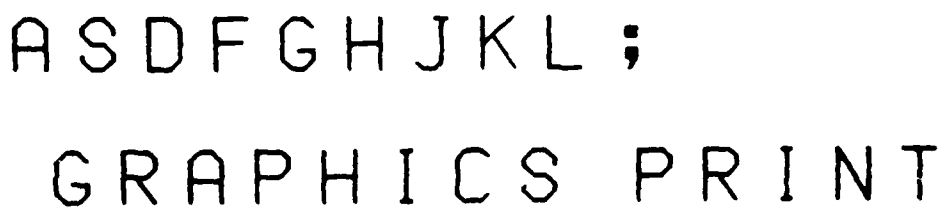

Figure 2. All of this print is scale factor 16. It should be remembered that this copy was made with a hard copy unit, decreasing the print size by a factor of 2. As stated on the print, the top two rows have a rotation of 2°.

Figure 3. Graphic print, scale factor 32, with a rotation of 5°. With the larger print, the greater rotation must be used to keep each line from overlapping the previous line. This copy was made with a hard copy unit and is therefore smaller by a factor of 2 than it would be on the terminal screen. This actual print size would appear as scale factor 16 on the terminal screen.

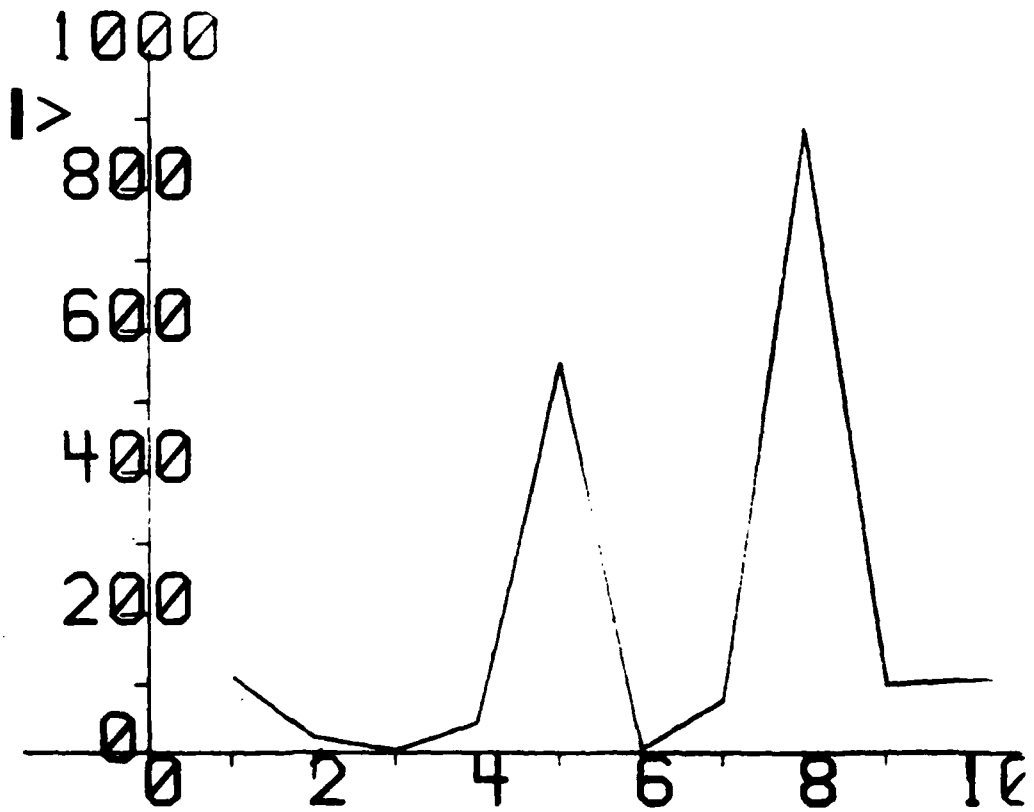

Figure 4. Use of the large print set with the Interactive Graphic Package. The graphic print set is turned on when the graph is transmitted to the terminal.

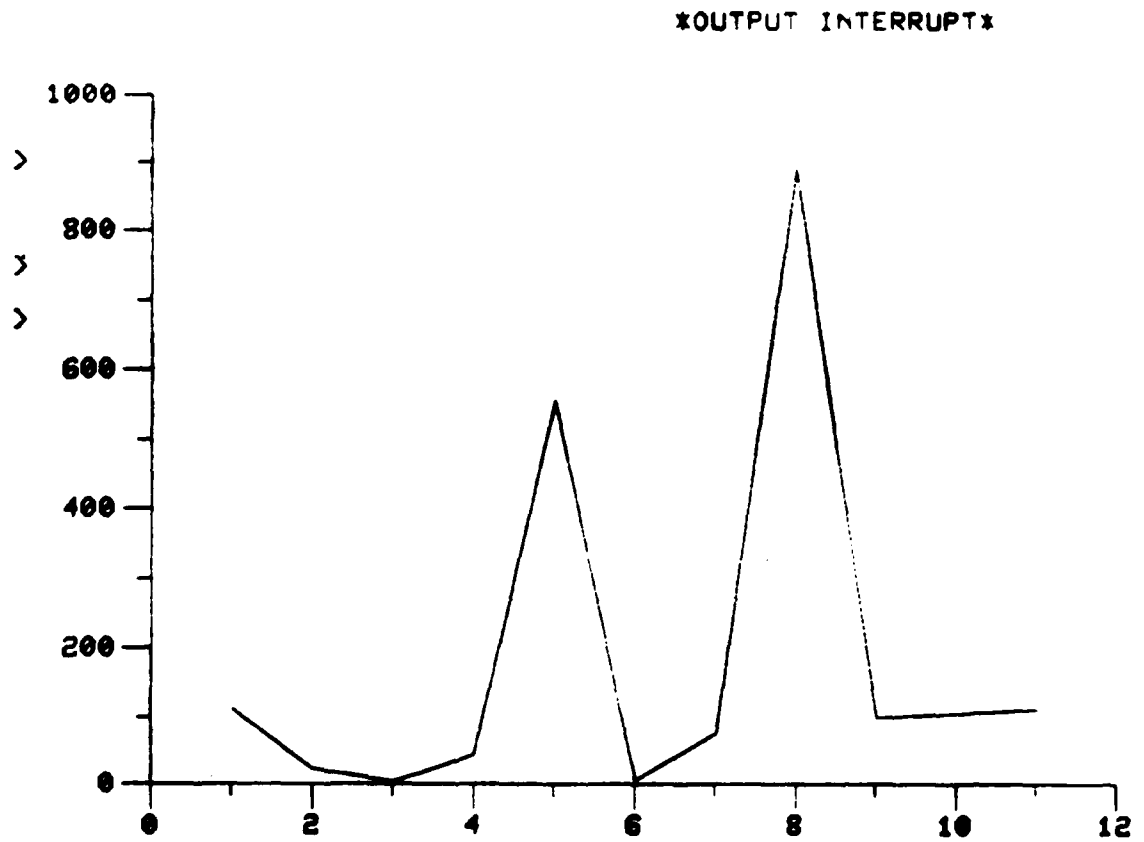

Figure 5. The same graph as in figure 4, but with the graphics print set turned off. The print that appears on this particular graph is the largest print set with which this terminal is equipped.

APPENDIX A

GRAPHIC PRINT SYSTEM

Hardware Description

The graphic print set software was developed and has been implemented on a Tektronix Model 4016-1 25-inch screen terminal equipped with options 40, 41, 5, and 27.

The terminal memory is volatile and must be reloaded each time the terminal power is turned on. For this purpose, the software is maintained on a floppy disc using the Tektronix Model 4907 File Manager mass storage device.

Hardcopy is obtainable in the developmental system from either the Tektronix model 4631 Dry Process Hard Copy Unit or from the Tektronix Model 4662 Interactive Digital Plotter.

Start-Up Procedure and Operational Notes

These directions are written from and directed to the point of view of a visually impaired operator who finds it an advantage to rely on audible as well as visual responses from the system, which might be of lesser interest to the fully sighted operator.

1. Turn on the 4907 File Manager floppy disc system 117-V ac power.

2. Load the graphics print set floppy disc completely into the 4907, until the floppy disc is caught. The label on the floppy disc must be up. Close the 4907 drive system door by pressing down on the long rectangular bar just above the floppy disc slot. A latch clicks when the bar is completely down.

3. Turn on the 4016-1 terminal 117-V ac power. The screen will slowly turn a fluorescent green over a period of about 2 minutes. When the screen is fully illuminated, press the "shift" and "page" keys together. The screen should go dark, and in about 30 seconds the phrase "G.P.I.B. Initialized" should appear in the upper left corner of the screen.

4. Type !ON(CR) to turn on the microprocessor in the terminal. [(CR) indicates pressing the carriage return key.] To check all steps up to this point, type ! six times. The phrase "Illegal Command" should flash on the screen three times, one below the other. This indicates that all steps have gone properly so far. Press (CR) to ready the system for the next command.

5. Set the date and time in the 4907 File Manager system by typing !TIME(SP)16-Aug-81.09:44:32(CR). All such commands on the terminal start with the !. Follow the ! with TIME, leaving no space between. Follow TIME with one space and the number for the day of the month, 16 in this example. A dash is required between the day and month and between the month and year. The month is written as the first three letters of the name of the month (e.g., Aug). A period, but no space, must separate the year (81) from the hour (09),

with colons separating the hour from the minutes (44) and the minutes from the seconds (32). A (CR) must follow immediately after the seconds.

6. Type !SET DI1-1(CR). This command tells the microprocessor that the floppy disc is present and that its address is 1. At this point, if everything has been performed correctly, the bell will sound. If the bell does not sound, repeat steps 5 and 6.

7. Type !MOUNT DI1(CR). This readies the floppy disc in the unit. If the command went properly, the bell will sound. If the bell does not sound, repeat this command.

8. The system should now be ready to copy software from the floppy disc to the terminal memory. The graphics information for the print set in this example is stored in file KEYS$ on the floppy disc. The command is !COPY DI1.KEYS$ TD(CR). This takes the file KEYS$ from disc and copies it to terminal memory. If the command is taken correctly, one can hear the heads shift several times in the floppy disc unit. When the command is completed, the bell will sound. If the bell does not sound or the disc heads do not shift, step 8 should be repeated.

9. Finally, the operator selects the desired character size and turns on the graphics print set by pressing "shift" and "2" simultaneously and then pressing key A, S, D, or F. The graphics print set should then be fully operational.

Pressing "shift" and "2" together puts the terminal into "expand" operation. This operation executes the commands stored in the "learn" segment of terminal memory that is associated with the next key pressed. In this case, each segment, whose contents were transferred to the terminal memory from the floppy disc during step eight, contains a string of four commands for the terminal.

The first three commands in each string select the scale factor and set the appropriate center position and rotation angle, respectively. The fourth command, which is the same for each string, turns on the graphics print set. The scale factors referenced to each letter are A = 16, S = 24, D = 30, and F = 36. (The equivalent print sizes are A = three-fourths inch, S = 1 inch, D = 1-1/4 inch, and F = 1-1/2 inch.) Proper adjustment of the center position ensures that each line of print contains a whole number of characters. As discussed earlier, the rotation angle prevents overlapping of lines.

To change print sizes after the graphics print set is already in operation, the operator must first turn the graphics off by typing !CHA N(CR). The operator then simply repeats step nine, selecting the letter that is referenced to the desired print size. The new print size will then be ready for use.

The turn-on procedure is repeated here in brief form:

1. Turn on power to floppy disc unit

2. Load floppy disc

3. Turn on power to terminal

4. !ON(CR) (turn on microprocessor)

5. !TIME 16-Aug-81.09:44:32(CR) (enter date/time)

6. !SET DI1-1(CR) (tell microprocessor the disc is there)

7. !MOUNT DI1(CR) (start floppy disc)

8. !COPY DI1.KEYS$ TD(CR) (copy software)

9. Shift 2, A (turn on graphic print set with scale factor of 16)

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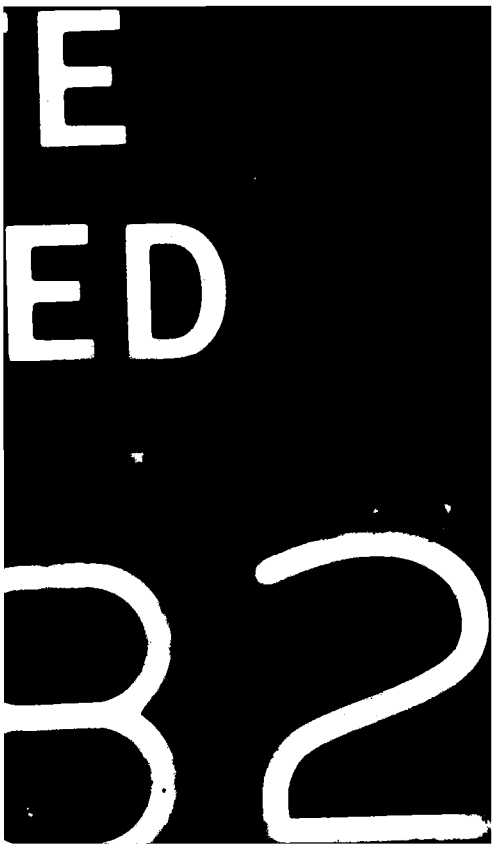
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